Evaluating Cloud Microphysics in High-Resolution WRF Simulations for Next Generation Climate Models

Research Highlight

As "high-performance" computing resources and technology advance, the next generation of climate models is going to be "convective resolving" (less than 10-km resolutions), or so-called "cloud permitting". At such high spatial and temporal resolutions, the truth gained from traditional single-column model performance may be INVALID. Because convective processes are not parameterized as in current generation climate models, the detailed cloud microphysics becomes one of the key parameterizations that play the most significant role in next generation climate models. Therefore, the evaluation of those cloud microphysical parameterizations becomes urgently needed and critically important to the success of the next generation of climate models in order to ensure VALID future projections of climate changes.

Based on recent observations gathered from the Tropical Warm Pool International Cloud Experiment (TWP-ICE, Darwin, 2006), we have conducted a suite of "cloud permitting" evaluations for three sophisticated six-class, bulk cloud microphysics in the advanced (single) dynamical modeling platform: the Weather Research and Forecasting (WRF) model. This evaluation is considerably different from previous ones because the WRF dynamical core is built on top of the fully compressible, non-hydrostatic Euler equations with terrain following Eta-coordinate, and the only parameterization changed is the cloud microphysics. The bulk cloud microphysics assumes a prescribed size distribution for six-class hydrometeors and only produces the mass, except for one microphysics (Thompson scheme), which also diagnoses the number concentration of cloud ice. Our systematical evaluation under uniform platform of code and initial and lateral boundary conditions ensures that the wide discrepancy results were caused only by the different cloud parameterization and its interactions with other physical parameterizations.

Our preliminary evaluations using a 2-D idealized thunderstorm simulation (250-m resolution) illustrate the wide discrepancy of the "ice-phase" cloud microphysics (Fig. 1) because other physical parameterizations and interactions were turned off. The TWP-ICE simulations (4-km resolution) again confirm that the "ice-phase" parameterization of cloud microphysics contributes most to the wide discrepancy between models and observations (Fig. 2). To further illustrate the potential influence of the cloud-radiation feedback, we have carried out another set of model evaluations, in which the interactions between cloud and radiation parameterizations (both longwave and shortwave) have been turned off. Our findings highlight the importance of "ice-phase" cloud parameterization, while the interactions between cloud and radiation plays a secondary, non-negligible role in contributing to the wide discrepancy (figures not shown).

Reference:

Wang Y, CN Long, LR Leung, J Dudhia, SA McFarlane, JH Mather, SJ Ghan, and X Liu. 2009. "Evaluating regional cloud-permitting simulations of the WRF model for the Tropical Warm Pool International Cloud Experiment (TWP-ICE, Darwin, 2006)." Journal of Geophysical Research-Atmosphere, 114, in press, doi:10.1029/2009JD012729.

Reference(s)

Contributors

Yi Wang, *Pacific Northwest National Laboratory*; Chuck N. Long, *Pacific Northwest National Laboratory*; L. Ruby Leung, *Pacific Northwest National Laboratory*; Jimy

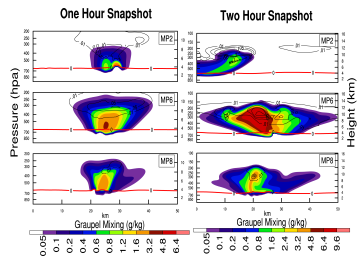

Figure 1. One-hour snapshot (left panel) and two-hour snapshot (right panel) of missing ratios (units g/kg) for graupel (shades) and cloud ice (contours) from idealized thunderstorm experiments. Contour levels for MP2, MP6 and MP8 (0.01, 0.05, 0.1, 0.2, 0.4).

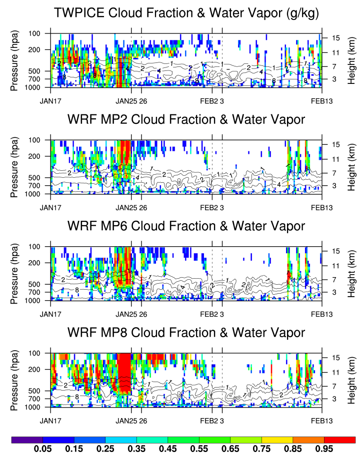

Figure 2. Cloud fraction comparison from the objective analysis (ARM ARSCL data) and WRF TWP-ICE experiments. On top of cloud fraction (non unit, shading), we also plot the water vapor mixing ratio (units g/kg) in contour levels of 1, 2, 4, 8, and 16.

Dudhia, *National Center for Atmospheric Research*; Sally A. McFarlane, *Pacific Northwest National Laboratory*; James H. Mather, *Pacific Northwest National Laboratory*; Steven J. Ghan, *Pacific Northwest National Laboratory*; Xiaodong Liu, *Institute of Earth Environment*

Working Group(s)
Cloud Modeling